



U.S. Department  
of Transportation  
**Federal Aviation  
Administration**

**AC:** 20-131A

**DATE:** 3/29/93

# **Advisory Circular**

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**AIRWORTHINESS APPROVAL OF TRAFFIC ALERT  
AND COLLISION AVOIDANCE SYSTEMS (TCAS II)  
AND MODE S TRANSPONDERS**

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Subject:	AIRWORTHINESS APPROVAL OF	Date: 3/29/93	AC No: 20-131A
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1. PURPOSE. This advisory circular (AC) provides guidance material for the airworthiness approval of Traffic Alert and Collision Avoidance Systems (TCAS II) and Mode S transponders. Like all AC material, this AC is not mandatory and does not constitute a regulation. It is issued for guidance purposes and to outline a method of compliance with the rules. In lieu of following this method without deviation, the applicant may elect to follow an alternative method, provided the alternative method is also found by the Federal Aviation Administration (FAA) to be an acceptable means of complying with the requirements of the Federal Aviation Regulations (FAR). Because the method of compliance presented in this AC is not mandatory, the terms "shall" and "must" used herein apply only to an applicant who chooses to follow this particular method without deviation.

2. CANCELLATION. Advisory Circular 20-131, Airworthiness Approval of Traffic Alert and Collision Avoidance Systems (TCAS II) and Mode S Transponders, dated October 3, 1988, is cancelled.

3. RELATED DOCUMENTS.

a. Related Federal Aviation Regulations. Portions of the FAR, as presently written, can be applied for the design, substantiation, certification and operational approval of TCAS II and Mode S transponders. Sections which prescribe requirements for these types of systems include:

- § 25.301 Loads.
  - § 25.303 Factor of safety.
  - § 25.305 Strength and deformation.
  - § 25.561 Emergency Landing Conditions--General.
  - § 25.603 Materials.
  - § 25.609 Protection of structure.
  - § 25.629 Flutter, deformation, and fail-safe criteria.
  - § 25.1301 Function and installation.
  - § 25.1303 Flight and navigation instruments.
  - § 25.1307 Miscellaneous equipment.
  - § 25.1309 Equipment, systems, and installations.
  - § 25.1321 Arrangement and visibility.
  - § 25.1322 Warning, caution, and advisory lights.
  - § 25.1331 Instruments using a power supply.
  - § 25.1333 Instrument systems.
  - § 25.1335 Flight director systems.
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- § 25.1351 Electrical Systems and Equipment: General.
- § 25.1353 Electrical equipment and installations.
- § 25.1355 Distribution system.
- § 25.1357 Circuit protective devices.
- § 25.1381 Instrument lights.
- § 25.1431 Electronic equipment.
- § 25.1541 Markings and Placards: General.
- § 25.1581 Airplane Flight Manual: General.
- § 25.1585 Operating procedures.

b. Advisory Circulars.

- AC 20-115A Radio Technical Commission for Aeronautics Document RTCA/DO-178A.
- AC 25.1309-1A System Design and Analysis.
- AC 25-11 Transport Category Airplane Electronic Display Systems.
- AC 120-XX Procedures and Criteria for Determining the Type Rating Requirements for an Aircraft.
- AC 120-55 Air Carrier Operational Approval and Use of TCAS II.

c. Technical Standard Orders.

- TSO-C112 Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment.
- TSO-C119a Traffic Alert and Collision Avoidance System (TCAS) Airborne Equipment, TCAS II.

d. Industry Documents.

(1) Radio Technical Commission for Aeronautics (RTCA) document DO-160C, Environmental Conditions and Test Procedures for Airborne Equipment; RTCA document DO-178A, Software Considerations in Airborne Systems and Equipment Certifications; RTCA document DO-181, Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment; RTCA document DO-185, Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance Systems (TCAS) Airborne Equipment. These documents can be obtained from the RTCA, One McPherson Square, Suite 500, 1425 Street Northwest, Washington, D.C. 20005.

(2) Aerospace Recommended Practice (ARP) 926A, Fault/Failure Analysis Procedure; ARP 1834, Fault/Failure Analysis Guidelines for Digital Equipment; and ARP 1068A, Flight Deck Instrumentation, Display Criteria and Associated Controls for Transport Aircraft. These documents are available from the Society of Automotive Engineers, Inc. (SAE), 400 Commonwealth Drive, Warrendale, PA 15096.

4. DEFINITIONS. The following definitions are applicable to this AC.

a. Advisory. A message given to alert the crew of converging aircraft and/or a potential collision.

b. Air traffic control (ATC). A generic term for a joint civil/military system for controlling traffic within a specific area.

c. Air traffic control radar beacon system (ATCRBS). A secondary surveillance radar system having ground-based interrogators and airborne transponders capable of operation on Modes A and C.

d. Alert. Indicator (aural or visual) which provides information to the flightcrew in a timely manner about a converging aircraft or a potential collision.

e. Coast. In the event of TCAS II momentarily developing the track of an intruder, a memory feature of the traffic display causes the traffic symbol to continue to move in the same direction and at the same speed as the original target.

f. Corrective resolution advisory. A resolution advisory that advises the pilot to deviate from current vertical speed, e.g., CLIMB when the aircraft is level.

g. Discrete. A separate, complete and distinct signal.

h. Failure. The inability of a system, subsystem, unit, or part to perform within previously specified limits.

i. False advisory. An advisory caused by a false track or a TCAS malfunction.

j. Fruit. Intruder replies corrupted by the receipt of undesired transponder replies that were elicited by ground interrogators and other TCAS II interrogators.

k. Incorrect resolution advisory. A resolution advisory which occurs when a threat is present, but, because of a failure of the installed TCAS II, Mode S transponder, or associated sensors, commands a maneuver which reduces separation to the threat.

l. Intruder. A target that has been determined by the TCAS II logic to be a converging aircraft which requires a traffic advisory.

m. Mode A. Type of secondary surveillance radar (SSR) equipment which provides a selected 4096 code reply (nonaltitude) when interrogated.

n. Mode C. Type of secondary surveillance radar (SSR) equipment which provides a reply with aircraft altitude information when interrogated.

o. Mode S. Type of secondary surveillance radar (SSR) equipment which provides replies to Mode A and Mode C interrogations and discrete address interrogations from the ground or air.

p. Other traffic. Aircraft more than  $\pm 1200$  feet vertical and 6NM from your aircraft which cause neither an RA nor a TA.

q. Preventive resolution. A resolution advisory that advises the pilot to avoid certain deviations from the current vertical speed because certain vertical speed restrictions exist.

r. Proximate traffic. Nearby aircraft within  $\pm 1200$  feet vertical and 6 NM which cause neither an RA nor a TA.

s. Resolution advisory (RA). Aural and visual information provided to the flightcrew to avoid a potential collision.

t. Resolution display. A display which shows vertical guidance depicting areas to "fly-to" and/or avoid above or below the TCAS equipped aircraft.

u. Sense. A direction that a resolution advisory may take: Either UP or DOWN relative to existing flight path of own aircraft.

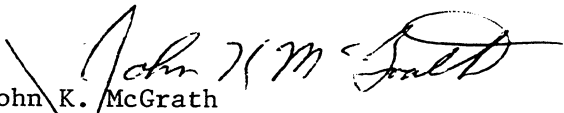
v. Threat. A target that has satisfied the threat detection logic and thus requires a resolution advisory (RA).

w. Traffic. An aircraft within the surveillance range of TCAS.

x. Traffic advisory (TA). Information given to the pilot pertaining to the position of another aircraft in the immediate vicinity. The information contains no resolution information.

y. Traffic display. A display of the horizontal position of transponder equipped aircraft relative to the TCAS equipped aircraft.

5. SCOPE. The material provided in this AC addresses the design aspects, characteristics, mechanization, testing, and the criticality of system failure cases for TCAS II and Mode S transponders. The guidance material is directed at systems which provide traffic advisories and resolution advisories in the vertical axis only (TCAS II) and where the operational performance standards are defined in technical documents that were developed by a joint air transport industry/government group (RTCA Special Committee SC-147).

  
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1. BACKGROUND. The airline industry has been working through the Air Transport Association since 1955 to find a workable collision avoidance system. It was not until the mid-1970s, however, that research centered upon the use of signals from ATCRBS airborne transponders as the cooperative element of a collision avoidance system. This technical approach allows a collision avoidance capability on the flightdeck which is independent of the ground system. In 1981, the FAA announced its decision to proceed with the implementation of an aircraft collision avoidance concept called the Traffic Alert and Collision Avoidance System (TCAS). The concept is based upon agency and industry development efforts in the areas of beacon-based collision avoidance systems and air-to-air discrete address communications techniques utilizing Mode S airborne transponder message formats.

A short time later, prototypes of TCAS II were installed on two Piedmont Airlines B-727 aircraft, and were flown on regularly scheduled flights. Although the displays were located outside the view of the flightcrew and were seen only by trained observers, these tests did provide valuable information on the frequency and circumstances of alerts and their potential for interaction with the ATC system. On a follow-on phase II program, a later version of TCAS II was installed on a single Piedmont Airlines B-727, and the system was certified in April 1986 and subsequently approved for operational evaluation in early 1987. Since the equipment was not developed to full standards, the system was only operated in visual meteorological conditions. Although the flightcrew operated the system, the evaluation was primarily for the purpose of data collection and its correlation with flightcrew and observer observation and response.

Later versions of TCAS II manufactured by Bendix/King Air Transport Avionics Division were installed and approved on United Airlines airplanes in early 1988. Similar units manufactured by Honeywell were installed and approved on Northwest Airlines airplanes in late 1988. This Limited Installation Program operated TCAS II units approved for operation as a full time system in both visual and instrument meteorological conditions on three different aircraft types. The operational evaluation programs continued through 1988 to validate the operational suitability of the systems.

2. SYSTEM DESCRIPTION. The TCAS II is an airborne traffic alert and collision avoidance system that interrogates ATC transponders in nearby aircraft and uses computer processing to identify and display potential and predicted collision threats. The system is designed to protect a volume of airspace around the TCAS II equipped aircraft. The system will provide appropriate aural and visual advisories to the flightcrew, to take action so as to ensure adequate separation, when the computer analysis of the intruding aircraft transponder replies predict a penetration of the protected airspace. The system provides two types of advisories. Traffic advisories indicate the

relative positions of intruding aircraft that are approximately 40 seconds from the closest point of approach and may a short time later require a resolution advisory. They also provide the flightcrew the opportunity to visually acquire the intruding aircraft. A resolution advisory will provide a vertical avoidance maneuver that will increase separation when the computer predicts the threat aircraft is within approximately 25 seconds from the closest point of approach.

The system provides two types of flightdeck displays. A traffic display indicates the relative position of ATC transponder equipped aircraft. A resolution display for each pilot indicates the appropriate vertical maneuver to avoid a threat. The TCAS II aircraft must be equipped with a Mode S ATC transponder which provides air-to-air communications for coordinating the resolution maneuvers between TCAS equipped aircraft. The Mode S transponder also provides discrete address replies to interrogations from ground stations and other TCAS II equipped aircraft.

The TCAS II system can only generate resolution advisories for intruders equipped with responding Mode S or Mode C transponders, which provide information on the altitude of the threat aircraft. Traffic advisories can be generated for aircraft with operative Mode S, Mode C or Mode A transponders. The TCAS II equipment is viewed as a supplement to the pilot who, with the aid of the ATC system, has the primary responsibility for avoiding mid-air collisions. The TCAS II system provides no indication of aircraft without operative transponders.

### 3. AIRWORTHINESS CONSIDERATIONS.

a. Certification Program. This AC provides guidance for the installation of TCAS II equipment and Mode S transponders. The system displays information and provides advisories in a number of formats. The degree of system integration to perform these functions is extensive and as a result, the applicant's program must be directed toward airworthiness approval through the type certification or supplemental type certification process.

b. Certification Plan. A comprehensive certification plan should be developed by the applicant. It should include how the applicant plans to comply with the applicable certification requirements and should provide a listing of the substantiating data and necessary tests. Also, a system description and an estimated time schedule should be included. A well developed plan will be of significant value both to the applicant and the FAA.

#### c. Equipment Installation.

(1) Mode S Transponder. A Mode S transponder is required for TCAS II operation. It is an enhanced version of existing ATCRBS transponders that is interoperative and compatible with the current ATCRBS system. Each aircraft equipped with a Mode S transponder is assigned a discrete address code. Mode S also provides the air-to-air data link between TCAS II equipped aircraft to coordinate resolution maneuvers. This ensures that the resolution advisory displayed in one TCAS II equipped aircraft is compatible with the maneuver displayed in the other TCAS II equipped aircraft. It has the capability to provide a data link between the equipped aircraft and the